

STUDIES ON THE SPECIES OF VINEGAR GNATS  
(DIPTERA: DROSOPHILIDAE) IN KANSAS

by

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## INTRODUCTION

During late summer through the fall season, there are many species of vinegar gnats which belong to the Dipterous family Drosophilidae in and around the homes. The flies are not of economic importance as far as direct damage is concerned, but rather because of the enormous numbers which at times become an annoyance. They are especially troublesome around homes in late summer during the canning season. They also enter the kitchen and sometimes accidentally fall into foods. They deposit eggs on the lid of a fruit jar that may not have been sealed tightly. These flies seek their food where it is most available to them and require only 11 days to produce a generation under favorable conditions.

The first problem in studying these flies was to collect species of Drosophilidae under the various ecological conditions existing in Kansas; the second, to determine how many species were actually known to exist in this state. Physiology and behavior patterns must be considered in selecting the best methods for collecting these flies.

Some of the important aspects of trapping flies are considered here, such as the type of baits used, the time of flies collected, and the temperature and the humidity requirement for maximum number of flies present in the baits.

Mass rearings on infested fruits especially those showing possibilities of Drosophilid infestation are a significant phase

of the study.

Most of the work was done in the Manhattan area during the past 16 weeks of school in the fall of 1950 and 1951.

Every home is equipped with either a garbage can or a garbage pail in the house and outdoors next to the kitchen. A few garbage can lids may be somewhat damaged and may not fit tightly. Under these conditions, the flies readily enter the garbage can to feed and deposit eggs for the coming generation. This is one of the reasons for the increase of species of vinegar gnats around the homes.

As a means of control, experiments were conducted under field conditions to test such means to prevent the flies from increasing within the garbage can.

#### REVIEW OF LITERATURE

Vinegar gnats are objectionable, not so much because of the damage they really do, but rather because of the enormous number which at times fairly take possession of an establishment.

Pavan, Dobzhansky and Burla (1950) reported a diurnal behavior pattern of Drosophila pseudoobscura Frolova with a close correlation to weather conditions, such as clear, warm, and dry days. The flies are active in the morning and before sunset and mostly quiescent during the middle of the day. No activities of flies during nights have been observed. In a humid rain forest with equable temperatures, or on rainy days, flies are active.

Methods of collecting species of Drosophila have been studied by Patterson (1943). He showed that the different species could be found in the following habitats: (1) parasitic on Cercopids; (2) fungi; (3) corallae of large flowers; (4) decaying fruits; (5) general scavengers--rotten potatoes, excrement, and stale formalized meat. Bonde (1939) reported two species, D. funebris and D. busckii, to be associated with decaying potatoes in Maine. Bitman et al. (1937) studied D. repleta on fermenting tomatoes with relation to canning of tomatoes. They found that the female of D. repleta laid 430 eggs during a week, averaging 14.84 eggs per day at 77° to 86° F.

Dobzhansky and Epling (1944) established a standard technique of collecting by means of baited traps. The success of a trap depends on the nature and the quantity of the bait, on the condition of the flies, on the weather, and on the presence or absence of other sources of attraction in the environment. Attractive radius of a banana trap on D. pseudobscura was 40 or 60 meters at two stations in the pine and pine-oak forests of the Southern California mountains. The best catches were made during a period of 30 to 50 per cent humidity and 47° to 90° F. range in temperatures.

Sister Geisler (1942) studied the effects of humidity on D. melanogaster pupae and found that lower humidity increased the mortality to a greater extent than did 100 per cent humidity.

Kalmus (1945) carried out a 14 months study on the popula-

tion of equal numbers of wild type and the ebony type of D. melanogaster. High temperature was found to favor the wild type and low temperature the ebony mutant type. Also, heterozygotes are superior to both homozygotes.

In 1943, Northrop found that an insufficient quantity of food retarded the growth of Drosophila flies. Sterile fruits, or fruits containing no yeast, caused a vitamin deficiency in the flies.

Spencer (1937) proposed a new technique for studying Drosophila eggs and larvae. He constructed a tiny metal ring cage where a single female fly can oviposit her eggs.

Parker (1935), at the University of Texas laboratory, reported the use of commercial mold preventive in Drosophila culture media. Moldex-A (a commercial trade name) is composed of the sodium salt of para-hydroxybenzoic acid. A small amount of this substance added to the food will stop the mold growth. Also, mites in the culture could be eliminated by heat sterilization.

Spieth (1951) reported that D. lacicola Patterson in Minnesota is known to breed in a narrow fringe about a pond where the rotting phloem of Aspen, Populus tremuloides Michx., is to be found. The larvae live on the yeasts which are formed in the rich aspen bark.

In 1937, Galtsoff reported on the principal methods of making culture media for Drosophila. Bridges (1921) formulated the first simple banana culture media consisting of 100 grams of banana, 100 cc of water, and 2 grams of agar-agar. Bridges and

Darby (1933) found a cheaper method of making a standard medium for laboratory use. The following is their formula: 75 cc of water, 10 grams of cornmeal, 13.5 cc of molasses, and 1.5 grams of agar.

Lewis (1942) during the war substituted tomato-paste medium for banana. He used 1,000 cc of water, 100 grams of tomato-paste (canned), 100 grams of white corn syrup, 20 grams of granulated agar-agar, and one gram of Moldex. The culture lasted for four weeks without drying out.

Blaufus (1936) discussed rearing method for D. melanogaster by the use of quart milk bottles.

Kalmus (1943) experimented on the mineral requirement of D. melanogaster. He reported that  $K_2HPO_4$  and  $MgSO_4$  were necessary for their diet. He designed the following media for Drosophila culture: 891 grams of  $H_2O$ , 20 grams of agar, 5 grams of tartaric acid, 80 grams of sucrose, 1.5 grams of  $K_2HPO_4$ , 2 grams of  $(NH_4)_2SO_4$ , and 0.5 gram of  $MgSO_4 \cdot 7 H_2O$ .

Spencer (1937) reported that D. funebris was attracted to human and animal excrement. Also Dove (1937) reported on a case of human intestinal myiasis with D. funebris larvae as the infesting insect. Smart (1943) reported that Drosophila maggots could be swallowed in food and thus be found in cases of intestinal myiasis.

DeCoursey (1925) points out that D. melanogaster becomes a pest in groceries and homes. He suggested a practical control in the form of a trap baited with fermenting banana around homes.

In 1935, McDaniel reported on the life cycle and control of species of Drosophila. She suggested three ways of decreasing the population of Drosophila in the community: (a) proper disposal of fruit waste; (b) don't leave fruits lying on the ice-box or near window--keep the fruits covered in a receptacle or put them in ice-box; and (c) fruits canned while in process should be sealed with rubber rings or paraffin. For insecticide control, she recommended a kerosene and pyrethrum mixture consisting of eight ounces of Pyrethrum to one gallon of kerosene mixed and settled for 24 hours. Then, pour off the clear liquid at the top and use for spraying.

According to McLeod (1944) the use of nicotine sulphate resulted in a higher mortality rate for the female than the male Drosophila.

Sloan (1945) recommended a dust consisting of 10 parts of lead arsenate, 6 parts of sulfur, and 4 parts of cupric carbonic acid for field use.

Metcalf (1948) used the fluorine analogue of DDT, commonly known as DFDT--fluoro DDT or fluogogessarol. The tests were made on adult D. melanogaster Meigen by impregnating 9-cm filter paper with 1 ml of standard acetone solution of DFDT. In 24 hours, the mortality rate was 63 per cent "knockdown" with 0.16 microgram concentration of toxicant applied per square centimeter of filter paper.

## SPECIES OF DROSOPHILIDAE OCCURRING IN KANSAS

## Previous Records of Drosophilidae in Kansas

Snow (1903) listed Drosophila ampelophila Loew (synonym of Drosophila melanogaster Meigen) as the only known species in Kansas in 1903. Crevecoeur (1905) added Phortica vittata Coq. to the list of Drosophilidae in Kansas. The latter species is now placed in the genus Scaptomyza. Tucker (1906) has added four additional species to the list of Drosophilidae. The following were the ones in Tucker's list:

Drosophila (Scaptomyza) adusta Loew.

Drosophila (Chymomyza) amoena Loew.

Drosophila funebris Fab.

Drosophila (Scaptomyza) graminum Fal.

He listed Scaptomyza as a subgenus of Drosophila. In the recent list of family Drosophilidae by Sturtevant (1921), Scaptomyza has been considered to be a separate genera. The Drosophila amoena Loew. recorded by Tucker has been placed in the genus Chymomyza. All species have been confirmed in the present study and added to the list of Drosophilidae in Kansas. Sturtevant (1921) listed several genera and species in Kansas under "geographical distribution". The following were the genera and species in his Kansas list:

Aulacigaster leucopeza (Meigen)

Chymomyza amoena (Loew.)

Chymomyza procnemis Williston  
Leucophenga maculosa (Dufour)  
Leucophenga varia (Walker)  
Scaptomyza adusta (Loew.)  
Scaptomyza graminum (Fallen)  
Drosophila affinis Sturtevant  
Drosophila busckii Coquillett  
Drosophila funebris (Fabricius)  
Drosophila melanogaster Meigen

Species Collected During this Study

Species of the following four genera were collected during the course of this investigation: Mycodrosophila, Chymomyza, Scaptomyza, and Drosophila. In all except genus Drosophila, only one or two species were collected. But under the genus Drosophila, there were 16 species. Among these 19 species which have been collected during the investigation, one genus and 13 species have not been recorded previously in the list of Diptera in Kansas. The following were the previously unrecorded species now added to those known to occur in Kansas (see Table 1 for host records and locality):

Mycodrosophila dimidiata Loew.  
Drosophila algonquin Sturtevant and Dobzhansky  
Drosophila athabasca Sturtevant and Dobzhansky  
Drosophila americana Spencer

Drosophila immigrans Sturtevant  
Drosophila guttifera Walker  
Drosophila hydei Sturtevant  
Drosophila melanica Sturtevant  
Drosophila putrida Sturtevant  
Drosophila repleta Wollaston  
Drosophila robusta Sturtevant  
Drosophila tripunctata Loew.  
Drosophila simulans Sturtevant

The external morphology of the species D. melanogaster and D. simulans is very similar, except the length of the compound eye vertically is slightly longer in D. simulans. Lots of specimens either trapped or reared and included under D. melanogaster probably included both D. melanogaster and D. simulans.

Members of the repleta group are composed of about 30 known species characterized by grayish spotted mesonotum, with each hair and bristle arising from a dark brown or black spot. There are several species under the subgroup of repleta which are difficult to separate.

#### Comparison of Kansas Drosophilidae with Four States Bordering the State

The geographical distribution of the various species of Drosophilidae may be discussed here in comparison with those known from the four states bordering Kansas.

Missouri. In 1941 (Patterson, 1943), there were 18 species

of Drosophila recorded from Missouri. Among the total number of species, 10 were the same as those known from Kansas. There were 14 species from Kansas not recorded from Missouri. These are as follows: Mycodrosophila dimidiata, Aulacigaster leucopeza, Leucophenga maculosa, Leucophenga varia, Chymomyza amoena, Chymomyza procnemis, Scaptomyza graminum, Scaptomyza adusta, D. algonquin, D. athabasca, D. americana, D. immigrans, D. guttifera, and D. simulans.

The 10 species similar to those found in Kansas were: D. busckii, D. melanogaster, D. affinis, D. putrida, D. repleta, D. tripunctata, D. funebris, D. hydei, D. robusta, and D. melanica.

Only one species from Missouri unknown to Kansas was D. macrospina.

Oklahoma. Collections recorded in 1941 (Patterson, 1943) included 22 species represented from Oklahoma. Among the total number of flies represented, there were 12 species of Drosophilidae identical to the species from Kansas. The following were the species recorded: Chymomyza amoena, D. busckii, D. melanogaster, D. simulans, D. affinis, D. putrida, D. tripunctata, D. funebris, D. repleta, D. hydei, D. robusta and D. melanica.

There were 12 species from Kansas not recorded from Oklahoma. These were as follows: Mycodrosophila dimidiata, Aulacigaster leucopeza, Leucophenga maculosa, Leucophenga varia, Chymomyza procnemis, Scaptomyza graminum, Scaptomyza adusta, D. algonquin, D. athabasca, D. americana, D. immigrans, and D. guttifera.

Several Oklahoma species unknown to Kansas were as follows: Gitona americana, D. duncani, D. transversa, D. texana, D. mulleri, D. macrospina, D. aldrichi, D. nigromelanica, and D. carbonaria.

Colorado. For Colorado, collection records (Patterson, 1943) included 14 species of Drosophilidae. There were 9 out of 14 species similar to those from Kansas. The 9 species are: Scaptomyza adusta, D. busckii, D. melanogaster, D. simulans, D. athabasca, D. funebris, D. repleta, D. hydei, and D. immigrans.

There were 15 species from Kansas not recorded from Colorado. These were as follows: Mycodrosophila dimidiata, Aulacigaster leucopeza, Leucophenga maculosa, Leucophenga varia, Chymomyza amoena, Chymomyza procnemis, Scaptomyza graminum, D. robusta, D. americana, D. algonquin, D. tripunctata, D. guttifera, D. putrida, D. melanica and D. affinis.

Several Colorado species unknown to Kansas were as follows: D. pseudoobscura, D. suboccidentalis, D. subquinaria, D. montana, and D. macroptera.

Nebraska. Williams (1948) collected and listed 22 species of Drosophilidae from Nebraska. From his listed species, 16 species were identical to Kansas species. These were as follows: Chymomyza amoena, Aulacigaster sp. Scaptomyza graminum, Chymomyza procnemis, D. melanogaster, D. affinis, D. algonquin, D. funebris, D. melanica, D. hydei, D. busckii, D. guttifera, D. robusta, D. putrida, and D. simulans.

There were 7 species from Kansas not recorded from Nebraska.

These were as follows: Mycodrosophila dimidiata, Leucophenga maculosa, Leucophenga varia, D. americana, D. athabasca, D. repleta, and D. tripunctata. The majority of the species caught in Nebraska were similar to those occurring in Kansas.

Several Nebraska species unknown to Kansas were as follows: D. macrospina, D. pseudocobscura, D. quinaria, D. transversa, D. pseudomelanica, D. victoria, D. macrospina, and D. cinera.

There were four species of Drosophilidae collected in Kansas but not recorded in any of the four states bordering the state of Kansas. These species are: Mycodrosophila dimidiata, Leucophenga maculosa, Leucophenga varia, and Drosophila americana.

The species Scaptomyza adusta, D. tripunctata, D. athabasca, and D. repleta represent the farthest north that these species have been found.

The most commonly known species from Kansas and also from Missouri, Oklahoma, Colorado, and Nebraska are D. funebris, D. melanogaster, D. simulans, D. putrida, D. busckii, and D. hydei.

The Patterson (1943) and Sturtevant (1921) taxonomic papers have been very useful as references in the systematic classification of Drosophilidae.

At present there are approximately 118 species listed in the classification of the genus Drosophila. Specimens of nearly all of the species listed in the collections have been sent to Dr. Marshall R. Wheeler of Texas University for determination or verification.

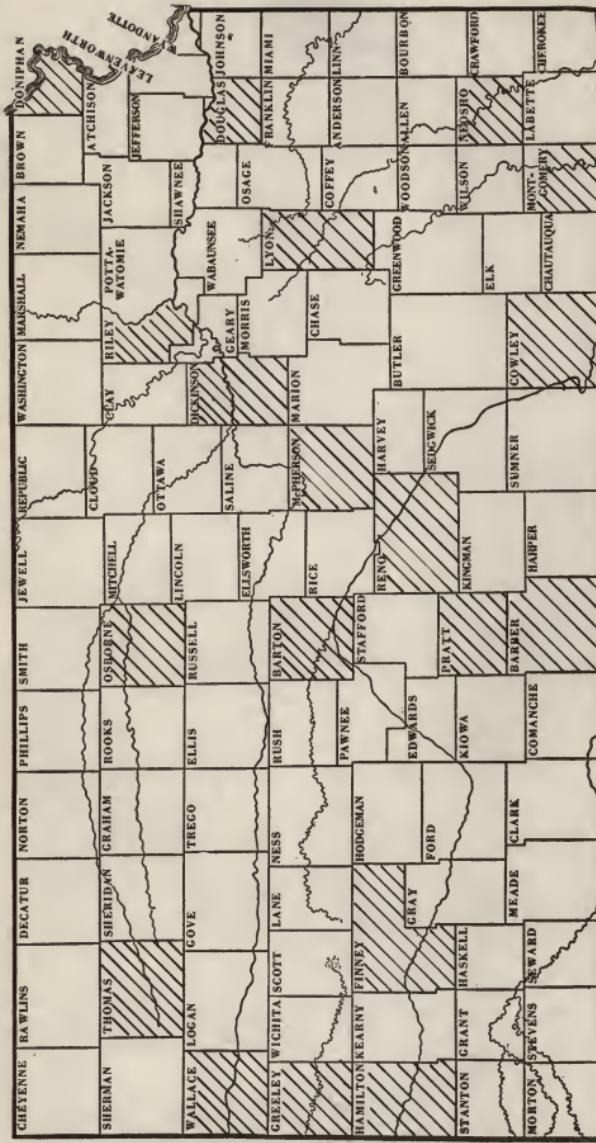


Fig. 1. Kansas counties from which Drosophilidae have been recorded.

Table 1. Species of Drosophilidae are listed with regard to the counties, the date of collection, and number of substrates from which they were either reared or trapped in Kansas.

Genus and species	Date collected	No. flies collected	County in Kansas	Substrate
<u><i>Mycodrosophila dimidiata</i> Loew.</u>	Sept. 26/50	4	Riley	Fungus
	Sept. 24/51	3	Riley	Fungus
	Sept. 18/50	1	Riley	Cucumber
<u><i>Scaptomyza adusta</i> Loew.</u>	April 29/34	1	McPherson	Apple
<u><i>Chymomyza amoena</i> Loew.</u>	Sept. 11/51	3	McPherson	Apple
	Sept. 8/51	2	Lyons	Pear
	Sept. 19/51	3	Riley	Banana
<u><i>Drosophila affinis</i> Sturz.</u>	Sept. 9/51	2	Barton	Crab apple
	Sept. 28/51	2	Riley	Crab apple
	Sept. 19/51	1	Riley	Banana
	Sept. 8/51	1	Lyons	Persimmon
	Sept. 24/51	1	Riley	Garbage
	May 29/51	1		Persimmon
	Oct. 28/51	2		Banana
	Sept. 24/51	1		Crab apple
<u><i>Drosophila allonguin</i> Sturz. and Dobz.</u>	Sept. 19/51	1		Banana
<u><i>Drosophila americana</i> Spencer</u>	May 28/51	1		Garbage
	Sept. 19/51	1		Banana
	Sept. 24/51	1		Persimmon
	Sept. 26/51	1		Apple
	Sept. 19/51	1		Banana
	Sept. 24/51	1		Crab apple
	Sept. 18/51	1		Banana
	Sept. 19/51	1		Banana
	May 27/51	3		Garbage
	Sept. 26/50	5		Pear
	Oct. 17/50	1		Persimmon
	Oct. 6/50	1		Grape
	Oct. 6/50	1		Pear

Table 1. (cont.)

Genus and species	Date collected	No. flies collected	County in Kansas	Substrate
<u>Drosophila funebris</u> Fab.	Sept. 26/50	1	Riley	Fungus
	Sept. 19/51	1	Riley	Tomato
	Sept. 19/51	3	Riley	Banana
	Sept. 9/51	6	Barton	Banana
	Sept. 28/51	3	Riley	
	Sept. 25/51	2	Riley	Mushroom
	Sept. 26/50	1	Riley	
	Sept. 19/51	1	Riley	
	May 21/51	1	Riley	Garbage
	May 29/51	1	Riley	Garbage
	Sept. 26/50	3	Doniphan	Pear
	Sept. 18/50	2	Riley	Persimmon
	Sept. 26/50	1	Riley	Fungus
	Oct. 17/50	1	Riley	Persimmon
	Sept. 18/50	1	Riley	Persimmon
	Sept. 26/50	1	Doniphan	Pear
	Sept. 19/51	1	Riley	Banana
	Sept. 24/51	4	Riley	Crab apple
	Sept. 18/50	4	Riley	Banana
	Sept. 18/50	5	Riley	Cucumber
	Sept. 18/50	4	Riley	Mushroom
	Sept. 18/50	4	Riley	Tomato
	Oct. 19/50	5	Thomas	Banana
	Oct. 18/50	2	Greeley	Banana
	Oct. 6/50	2	Riley	Persimmon
	Oct. 6/50	2	Riley	Poteweed
	Oct. 18/50	1	Wallace	Prickly pear
	Oct. 17/50	2	Riley	Persimmon
	Oct. 17/50	2	Riley	Crape

Table 1. (cont.)

Genus and species	Date collected	No. flies collected	County in Kansas	Substrate
<u>Drosophila melanogaster</u> Meigen	Sept. 26/50	1	Riley	Apple
	Sept. 26/50	2	Riley	Persimmon
	Oct. 18/50	5	Finney	Banana
	Sept. 26/50	1	Riley	Apple
	May 26/51	3	Riley	Garbage
	May 27/51	5	Riley	Garbage
	May 28/51	3	Riley	Garbage
	May 29/51	5	Riley	Garbage
	May 30/51	3	Riley	Garbage
	May 31/51	4	Riley	Garbage
	Sept. 19/51	2	Riley	Garbage
	Sept. 9/51	12	Montgomery	Banana
	Sept. 9/51	6	Cowley	Banana
	Sept. 9/51	4	McPherson	Banana
	Sept. 9/51	5	Barton	Banana
	Oct. 7/51	6	Doniphan	Grape
	Oct. 7/51	8	Doniphan	Apple
	Sept. 24/51	1	Riley	Crab apple
	Sept. 8/51	3	Lyons	Apple
	Sept. 8/51	7	Lyons	Grape
	Sept. 9/51	11	Neosho	Banana
	Sept. 19/51	5	Riley	Banana
	Sept. 25/51	1	Riley	Crab apple
	Oct. 19/50	8	Thomas	Banana
	Sept. 26/50	4	Riley	Pokeweed
	Sept. 26/50	2	Riley	Apple
	Oct. 6/50	3	Riley	Grape
	Oct. 6/50	3	Doniphan	Pear
	Oct. 26/50	1	Doniphan	Grape
	Oct. 7/51	1	Wallace	Prickly pear
<u>Drosophila melanogaster and D. simulans</u>				
	Sept. 26/50	4	Riley	
	Oct. 6/50	2	Riley	
	Oct. 6/50	3	Riley	
	Oct. 26/50	1	Riley	
	Oct. 7/51	1	Doniphan	
	Oct. 18/50	4	Wallace	

Table 1. (concl.)

Genus and species	Date collected	No. flies collected	County in Kansas	Substrate
<u>Drosophila melanogaster</u> and <u>similans</u>	Sept. 18/50	2	Riley	Cucumber
	Sept. 18/50	4	Riley	Mushroom
	Sept. 18/50	3	Riley	Tomato
	Sept. 18/50	7	Riley	Banana
	Sept. 24/51	1	Riley	Banana
<u>Drosophila putrida</u> Sturt.	Oct. 10/32	1	Douglas	Cucumber
	Sept. 8/50	1	Riley	Cucumber
	Oct. 5/32	1	Douglas	Mushroom
	Sept. 26/50	2	Riley	Cucumber
	Sept. 18/50	1	Riley	Crab apple
	Sept. 8/49	1	Riley	Banana
	Sept. 7/51	4	Douglas	Persimmon
	Sept. 28/51	1	Riley	Banana
	Sept. 19/51	2	Riley	Persimmon
	Oct. 17/50	1	Riley	Banana
	Oct. 8/38	1	Riley	Crab apple
	Oct. 30/50	1	Riley	Banana
	Oct. 30/50	1	Riley	Tomato
	Sept. 22	1	Reno	
<u>D. repleta</u> group	Oct. 23/51	2	Riley	
	Sept. 25/51	1	Riley	
	Sept. 28/51	1	Riley	
<u>D. robusta</u> Sturt.	Oct. 17/51	1	Riley	
	Sept. 19/51	2	Riley	
	Sept. 24/51	1	Riley	
	Sept. 28/50	2	Riley	
<u>Drosophila similans</u> Sturt.	Sept. 19/51	1	Riley	
<u>Drosophila tripunctata</u> Loew.	May 29/51	1	Riley	
	Sept. 18/50	2	Riley	

### Habitat of Species

Several species of Drosophilidae are known to have distinct kinds of food on which they feed and breed. The foods around the Midwest region are most plentiful during middle and late summer. The natural production of food supply from cultivated farms, fields, and forests in this area can furnish these flies with a variety of foods. Also, garbage pails in homes and garbage cans outdoors can be good feeding places as well as breeding places for the flies. Most of the species of Drosophilidae can be best collected by attention to their natural selection of foods. Therefore, the collection of Drosophilidae may be difficult unless it is a common species such as D. melanogaster that feeds on most of the available fruits in Kansas.

Flies are more apt to feed on semi-liquid to liquid foods. All of the food represented in Table 1 were in these two categories. Some of the more common species of Drosophila caught were recorded in Table 2. The species Drosophila melanogaster Meigen for example showed its great abundance by the number of times caught during September to October of 1950 and 1951. Usually there were at least 50 per cent D. melanogaster in every trap.

The species collected in Kansas may be placed into three general divisions. There were the general scavengers, the fruit-feeders, and the fungus-feeders.

Table 2. Survey of species populations of Drosophilidae in Kansas with number of times trapped or reared using 15 types of substrates.

C = Species collected  
B = Species named

The general scavengers fed on decaying vegetables (such as potatoes, tomatoes, cucumbers) and refuse in garbage cans (such as bacon, meat, gravy, etc.). The species found on decaying vegetables were D. funebris, D. tripunctata, D. putrida, D. melanogaster, and Scaptomyza adusta. This group of species has been collected either through rearing from the infested host fruits or trapping near the decaying food. Those species feeding on the refuse in the garbage can were D. funebris, D. americana, D. busckii, D. affinis, D. hydei, and D. melanogaster. All of these species was first collected in 1951 during the month of May. The fruit-feeders, such as D. melanogaster, D. affinis, D. hydei and D. americana were attracted to garbage cans probably due to unavailable native foods during early summer.

The fruit-feeders fed largely on the available fruits either native or cultivated; but the majority of this group of species concentrated on the food easily found in Kansas. The common fruits were pear, peach, persimmon, apple, wild grape, cultivated grape, crab apple, prickly pear, pokeweed, banana, and Virginia creeper. Drosophila melanogaster was the only species collected from all the available foods in Kansas. This is indicated in Table 1 under the subheading "substrate", in which there are 15 different food items. The fruit-feeders were the largest among flies collected in Kansas.

The fungus-feeders were found on bracket fungus and mushrooms in Manhattan. Apparently most of the fungus species fed

and bred on warm summer months because few were found and collected during the late summer and early fall. This group included the following species: D. putrida, D. hydei, D. affinis and Mycodrosophila dimidiata.

List of Species in Kansas

Mycodrosophila dimidiata Loew. 1862 Berl. Ent. Zeit. 6; 231. This species was described as Drosophila dimidiata Loew.; later Sturtevant transferred as Mycodrosophila dimidiata Loew. (1918. Jour. N. Y. Ent. Soc., 26; 38).

Aulacigaster leucocopeza Meigen. 1830 Syst. Beschr. 6; 100. The European species were referred to the ephydriine genus Notiphila by Fallen (1910. Sp. Ent. nov. Dipt. 22; ), and to the Geomyzine genus Diastata by Meigen (1830. Syst. Beschr. Zweifl. Insekt. 6; 94).

Leucophenga maculosa Coquillett. 1895 Proc. Acad. Nat. Sci. Phila. 47; 317. This species is the European Drosophila maculata Dufour. Kahl transferred the species to Leucophenga (1917. Ann. Carnegie Mus., 11; 364).

Leucophenga varia Walker. 1849 List. Dipt. Ins. 4; This species was also described as Drosophila quadrimaculata Walker. (1856 Dipt. Saund., 4; ).

Chymomyza amoena Loew. 1862 Berl. Ent. Zeit. 6; 230. This species was described as Drosophila amoena Loew. (1862 Ent. Zeit. 6; 230); Sturtevant transferred it to Chymomyza (1916. Ann. Ent. Soc. Amer., 9; 325).

Chymomyza procnemis Williston. 1896 Trans. Ent. Soc. London, 412.

Scaptomyza adusta Loew. 1862 Berlin ent. Zeit. 6; 231. This species was described as Drosophila adusta Loew. Coquillett transferred to Scaptomyza (1910. Proc. U. S. Nat. Mus. 37; 603).

Scaptomyza graminum Fallen 1823. Dipt. Suec. Geomyz 2; 8. This species was described as Drosophila graminum Fallen; later Coquillett transferred it to Scaptomyza (1910. Proc. U. S. Nat. Mus., 37, 603).

Drosophila

D. affinis Sturtevant. 1916 Ann. Ent. Soc. Amer. 9; 334.

D. algonquin Sturtevant and Dobzhansky 1936. Amer. Nat. 70; 575.

D. (virilis) americana Spencer 1938. Geneticis 23; 169. Spencer described this form as a subspecies of Drosophila virilis Sturtevant.

D. athabasca Sturtevant and Dobzhansky 1936. Amer. Nat. 70; 576.

D. busckii Coquillett. 1901. Ent. News. 12; 18. This species was described as D. rubrostriata Becker and D. plurilineata Villeneuve; now Knab referred these two species to busckii (1918. Bul. Amer. Mus. Nat. Hist. 38; 445.).

D. funebris Fabricius 1787. Mant. Ins. 2; 345.

D. guttifera Walker 1849. List. Dipt. Ins., 4; 1110. This species was also described as D. multipunctata Loew. (1866 Berlin ent. Zeit., 10; 50).

D. hydei Sturtevant 1921. Pub. Carneg. Inst. Wash., Pub. 301; 101.

D. immigrans Sturtevant 1921. Pub. Carneg. Inst. Wash., Pub. 301; 83. This species was described as D. tripunctata (1918, Bul. Amer. Mus. Nat. Hist., 38; 445). by Sturtevant.

D. melanica Sturtevant 1916. Ann. Ent. Soc. Amer. 9; 332.

D. melanogaster Meigen. 1830 Syst. Beobhr. 6; 85. This species has also been known as D. nigriventris Zetterstedt (1847. Dipt. Scand. 6; 2557), D. uvarum Rondani (1875. Bul. Com. Agr. Parm.), and D. ampelophila Loew. (1862. Berlin ent. Zeit. 6; 231.).

D. putrida Sturtevant. 1916. Ann. Ent. Soc. Amer. 9; 339.

D. repleta Wollaston 1858. Ann. Mag. Nat. Hist. 41; 117.

D. robusta Sturtevant. 1916. Ann. Ent. Soc. Amer. 9; 331.

D. simulans Sturtevant. 1919. Psyche 26; 153.

D. tripunctata Loew. 1862. Berlin ent. Zeit., 6; 231. This species was also described as D. modesta Sturtevant 1916 (Ann. Ent. Soc. Amer., 9; 338).

## METHODS USED FOR COLLECTION

## Baits and Culture Media

As attractants or baits, peach, banana, apple, grape and tomato were used; among these, fermenting bananas were found to be the best. They are considered best because of the natural odor, outlasting other fruits and containing less water in the fruit.

From time to time, culture media were used as a substitute for the natural bait. Bridges' laboratory culture was extensively used. The formula is as follows: 100 grams of banana (peaches, pears or similar fruits were used), 100 cc of water, 2 grams of agar-agar. The medium was made by first heating the water, then adding the agar-agar and stirring until it dissolved. Then the crushed banana pulp was added to the heated agar. At the same time 0.5 gram of yeast was added. Then this mixture was allowed to stand for 24 hours before using. This gave time for the medium to cool and the accumulated gas in the jar to escape.

## Traps and Infested Fruits

The first problem was to collect these flies. There were several ways in which they were collected. On September 15, 1950 infested fruits of pears, peppers, and tomatoes were col-

lected at a garden in Manhattan. They were taken to the insectary in mayonnaise jars or similar vessels for rearing the flies (Table 3). Samples of flies reared were taken and pinned on minuten nadeln for further investigation.

Another method used was the banana trap. Ripe bananas were placed in the mayonnaise jar with two folded paper towels on the bottom of the jar. These were to absorb the excess moisture. The jars were exposed in various places for varying lengths of time from six hours to three days.

A dozen fly traps were placed in a vegetable garden next to the insectary. A stick was driven into the ground, and a jar tied to it about a foot from the ground so that other insects of the crawling type could not get into it.

Flies were also collected by sweeping over the infested fruits with an insect net. Flies were collected on infested or decaying cucumber, tomatoes, and squash by this method. Samples of flies were taken and pinned for determination.

At the garden near the insectary, ink-cap mushrooms of the black-spored gill fungi (Coprinus species) were found to have a few flies infesting the "ink". There were also house-flies (Muscidae) on the mushrooms. A cyanide bottle was used to collect a few specimens and the mushrooms were brought to the laboratory to rear the infesting insects (Table 3).

Other infested fruits brought in by friends increased the study area in Manhattan. Addresses sometimes were not clearly known, but the approximate locality has been marked on the city map (Fig. 2).

Table 3. Mass rearings from infested fruits and uninfested fruits show the possibilities of Drosophilidae infestation from five counties during September to October, 1950.

Kind of fruit	Locality	Species** and abundance of each
Green pepper	R	None
Tomato	R	(d) 14, (e) 5, (h) 3
Pear	R	(d) 55
Cucumber	R	(d) 90, (e) 20, (g) 10
Mushroom	R	(d) 20, (g) 10, (i) 5
Bracket fungus	R	(a) 7, (b) 12, (c) 6
Peach	R	(d) 200
Dogweed	P	None
Pokeweed	P	(d) 50, (e) 12
Virginia creeper ( <i>Pedera</i> , N. sp.)	P	(d) 15
Wild rose ( <i>Rosa</i> L. sp.)	P	None
Wild grape ( <i>Vitis</i> L. sp.)	P	(d) 10
<u><i>Euonymus americanus</i> L.</u>	R	None
<u><i>Euonymus atropurpureus</i></u> Jac.	R	None
<u><i>Elaeagnus umbellata</i> L.</u>	R	None
<u>Privet (<i>Ligustrum vulgare</i> L.)</u>	T	None
Persimmon	R	(d) 29, (b) 7, (c) 11, (f) 4
Prickly pear ( <i>Copuntia</i> sp.)	H	None
Prickly pear ( <i>Copuntia</i> sp.)	W	(d) 23, (e) 7
Apple (Staymen)	R	(d) 16, (e) 5
Crab apple ( <i>Malus ioensis</i> )	R	(d) 14
Hope crab ( <i>Malus baccata</i> )	R	(d) 10

\* H = Hamilton  
P = Pottawatomie  
R = Riley  
T = Thomas  
W = Wallace

\*\* (a) *Mycodrosophila dimidiata*  
(b) *Drosophila funebris*  
(c) *Drosophila hydei*  
(d) *Drosophila melanogaster*  
(e) *Drosophila melanogaster* and  
    *simulans*  
(f) *Drosophila repleta* group  
(g) *Drosophila putrida*  
(h) *Drosophila tripunctata*  
(i) *Drosophila simulans*

A colony of bracket fungus growing on an old tree stump at the southeast end of the campus was collected and insects reared from it (Tables 3 and 4). A few specimens of Drosophila from the fungus were etherized and placed in the collection box. Species of the family Muscidae were also represented in rearings from the fungus.

Next to the apiary, there was an area planted with corn belonging to the Department of Entomology. Four fly traps were placed under the trees and along the wire fence next to a wooded area nearby (Table 5). These traps were placed in the shade because the day time temperatures were high. The baits would have desiccated in the sun and there would have been little chance of catching the flies. A few specimens of Drosophila were taken from each jar for the collection or identification.

On October 6, some specimens were collected on the Horticultural Farm. Several jars with crushed grapes and apples were placed in the orchards. The following day, the jars were collected and brought back to the laboratory. The only fruits available at that time in the orchard were Staymen apples and grapes, since cherry and peach were out of season. Samples were collected earlier from Concord and Urbana grapes.

Fruits and berries in the neighborhood of the entomology greenhouse were caged for possible infestation. One of several traps was made by picking up ripe persimmons from the ground and putting them in collecting jars (Table 5). Three of these jars were strung from the branches of near-by shrubs to

Table 4. Mass rearings from infested fruits and with uninfested fruits show the possibilities of Drosophilidae infestation from four counties during September to October, 1951.

Kind of fruit	Locality*	Species**	and abundance of each
Green pepper	R	None	
Tomato	R	(c) 20, (d) 10, (f) 5	
Pear	R	(c) 38	
Peach	R	(c) 29	
Bracket fungus	R	(a) 3	
Virginia creeper ( <i>Pseuderis</i> , N. sp.)	R	(c) 8	
Crab apple ( <i>Malus ioensis</i> )	R	(b) 8, (c) 6	
Hope crab ( <i>Malus baccata</i> )	R	(b) 6, (c) 14	
Apple (Delicious)	L	(c) 34	
Grape (Concord)	L	(c) 14	
<i>Euonymus americanus</i> L.	R	None	
<i>Euonymus atropurpureus</i>	R	None	
Jaq.			
<i>Elaeagnus umbellata</i> L.	R	None	
Persimmon	R	(c) 25, (e) 7	
Apple (Delicious)	D	(c) 23	
Apple	C	(c) 13	

\* C = Cloud  
D = Dickinson  
L = Lyons  
R = Riley

\*\* (a) *Mycodrosophila dimidiata*  
(b) *Drosophila affinis*  
(c) *Drosophila melanogaster*  
(d) *Drosophila melanogaster* and  
    *simulans*  
(e) *Drosophila hydei*  
(f) *Drosophila tripunctata*

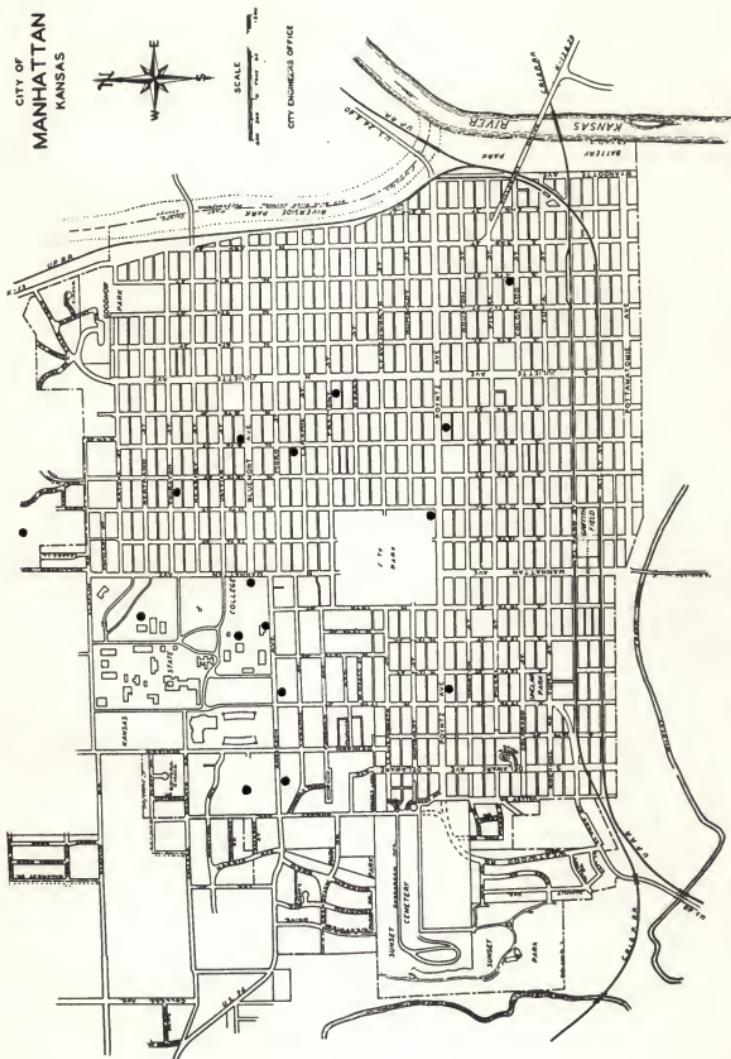


Fig. 2. Localities in Manhattan where collections of Drosophilidae were made by means of traps or by collecting infested fruits.

Table 5. Trapping data on *Drosophila* sp. using various fruits from different localities in Kansas in the fall of 1950. Humidity and temperature were taken from the hydrothermograph records of the Kansas State College Department of Physics.

Type & number of trap baits used	Localization	Time exposed: hrs.	Time caught: hrs.	Time of collection:	Humidity: %	Temperature: °F.	Species represented.	Remarks
Banana 1	Insectary garden	36	58	9:30 a.m.	87	60.5	D. melanogaster	
2		37	55	10:30 a.m.	88.5	61	D. melanogaster	
3		39	34	12:15 noon	87	70	D. melanogaster & D. busckii	
4		43	60	4:30 p.m.	85	71	D. melanogaster	
1		36	40	5:30 p.m.	35	70.5	D. melanogaster & <i>Scaptomyza adusta</i>	
2		36	45	5:30 p.m.	35	70.5	D. melanogaster & <i>Scaptomyza adusta</i>	
3		36½	25	6:00 p.m.	55	60.5	D. melanogaster & <i>Scaptomyza adusta</i>	
Pear 1	Manhattan	24	93	11:30 a.m.	82.5	80	D. melanogaster & <i>Scaptomyza adusta</i>	
Pear 2	Manhattan (College Cafeteria)	24	105	10:30 a.m.	83	78.5	D. melanogaster	

Table 5. (cont.)

Type & number of trap baits used	Locality	Time exposed: hrs.	Time of collection: hrs.	Humidity: %	Temperature: °F.	Species represented.	Remarks
Persimmon 1	Manhattan (school campus)	24	6	4:00 p.m.	64	D. <u>putrida</u>	D. <u>melanogaster</u>
1	Manhattan (school campus)	24	57	10:00 a.m.	59	D. <u>hydei</u>	D. <u>melanogaster</u>
2	Manhattan (school campus)	24	33	12:00 noon	53	D. <u>affinis</u>	
Staymen apple	Manhattan (Hort. Farm)	28	43	10:00 a.m.	52	D. <u>melanogaster</u> & <u>simulans</u>	D. <u>melanogaster</u> Day before collection was very windy.
Concord grape	Manhattan (Hort. Farm)	28	48	10:30 a.m.	52	D. <u>melanogaster</u> & <u>simulans</u>	D. <u>melanogaster</u> D. <u>funebris</u> D. <u>repleta</u> group Day before collection was very windy.
Urbana grape	Manhattan (Hort. Farm)	28	54	10:30 a.m.	52	D. <u>melanogaster</u>	Day before collection was very windy.

Table 5. (cont.)

Type & number of trap baits used	Localization	Time exposed: hrs.	Time of collection	Humidity: %	Temperature: °C	Species represented	Remarks
Banana 1	Manhattan (school campus east)	36	20	12:00 noon	45	D. melanogaster	
Banana 2	Manhattan (school campus west)	36	29	1:00 p.m.	44	D. melanogaster	
Pear	Doniphan	*	80			D. immigrans	
						D. busckii	
						D. hydei	
						D. melanogaster	
Banana peels	Colby	over-night	22	early morning	48	D. melanogaster	
	Syracuse	over-night	30	early morning	50	D. melanogaster	
	Garden City	1	32	12:00 noon	70	D. melanogaster	
	Goodland	over-night	none	early morning	42	D. melanogaster	
Banana media	Osborne	*	10	*	35	D. melanogaster	Culture media was too dry. Needed moisture.

Table 5. (concl.)

Type & number of trap baits used	Time exposed	Approx. no. of specimens	Time of collection	Humidity: %	Temperature: °F.	Species represented.
Banana media	Concordia	*	B	*	*	D. melanogaster
Banana media	Lyons	*	none	49	55	Media needed moisture. It was too cold.

\* Trapped by county agents.

The average temperature has been taken from the Climatological Data of Kansas.

try to obtain Drosophilidae eggs for rearing.

A professor brought in some fruits, and flies trapped on banana peels during a trip to western Kansas. He also collected ripened prickly pears from Hamilton and Wallace counties and brought them back to be caged for possible Drosophilidae infestations. The localities from which specimens were collected were Garden City, Colby, Syracuse, Sharon Springs, and Goodland, Kansas. Banana peels, and garden refuse were the chief items used as trap baits (Table 5).

Several times while the traps were being collected, there were butterflies (Styridae, Pieridae), houseflies (Muscidae), bluebottle flies (Calliphoridae), and honeybees (Apidae) present together with the Drosophilidae.

With the aid of Mr. Dell Gates, Extension Entomologist, contact was made with county agents for collecting flies in their respective counties. Instructions regarding an ideal spot where flies could be found were given. This material was then given to six county agents.

In middle of May, 1950, the first species of Drosophilidae have been seen around Manhattan. There were large populations of these flies concentrated in and around the garbage can outside the homes between Laramie and Moro Street in the 900 block. Traps were set near the garbage cans and the first collection of these flies was made on May 26, 1950 (Table 6).

A collection trip to eastern Kansas from September 8 through 11 was made through the aid of a friend. Some infested

Table 6. Trapping data on Drosophilidae using various fruits from different localities in Kansas in the fall of 1951. The humidity could not be obtained under field trip conditions. The average temperature has been taken from the Climatological Data of Kansas.

Type & number of trap baits used:	Localities	Time exposed:	approx. no. of specimens caught:	Time of collection:	Op.	Temperature:	Atmosphere:	Species represented.	Remarks
Banana	1 Olpe	2 $\frac{1}{2}$	5	4:20 p.m.	Avg.	68	D. melanogaster D. affinis		
	1 Chanute	over-night	9	9:00 a.m.		65	D. melanogaster		Raining very hard
	2 Chanute	over-night	11	9:00 a.m.		65	D. melanogaster		
	3 Chanute	over-night	5	9:00 a.m.		65	None		
	1 Caney	2	4	4:00 p.m.		70	D. melanogaster		It was dark & raining very hard
	2 Caney	2	6	4:00 p.m.		70	D. melanogaster		
	3 Caney	2	2	4:00 p.m.		70	D. melanogaster		
	1 Arkansas City	over-night	5	9:00 a.m.		70	D. melanogaster		It was a chilly morning.
	2 Arkansas City	over-night	8	9:00 a.m.		70	D. melanogaster		
	3 Arkansas City	over-night	3	9:00 a.m.		70	D. melanogaster		

Table 6. (cont.)

Type & number of trap baits used	Kansas locality	Approx. no. of hrs. trap. used	Time exposed	No. specimens caught	Time of collection	Op.	Temperature	Species represented.	Remarks
Pear 1	Arkansas City	over-night	7	9:00 a.m.	70	D. <u>melanoGaster</u>			
Banana 1	Medicine Lodge	1½	none	1:30 p.m.	69	It was a hot & humid day.			
		2	none	1:30 p.m.	69	It was a hot & humid day.			
		3	none	1:30 p.m.	69	It was a hot & humid day.			
		1	none	3:30 p.m.	67	It was a bright & sunny afternoon.			
		2	none	3:30 p.m.	67	It was a bright & sunny afternoon.			
		3	none	3:30 p.m.	67	It was a bright & sunny afternoon.			
		1	Great Bend	4	5:00 p.m.	65.5	D. <u>funebris</u>		
		2		5	5:00 p.m.	65.5	D. <u>affinis</u>		
		2		0	5:00 p.m.	65.5	D. <u>melanoGaster</u>		
		5					D. <u>affinis</u>		
		1	McPherson	over-night	3	9:00 a.m.	68	D. <u>melanoGaster</u>	
		2	McPherson	over-night	7	9:00 a.m.	68	D. <u>melanoGaster</u>	

Table 6. (cont.)

Type & number of trap baits used:	Kansas locality:	Time exposed:	approx. no. of specimens caught:	Time of collection:	temperature:	Species represented.
Banana 3	McPherson	over-night	10	9:00 a.m.	68	<u>D. melanogaster</u>
Apple 1	McPherson	over-night	15	9:00 a.m.	68	<u>D. melanogaster</u> <u>Thymomyza amoena</u>
Banana 1	Manhattan	over-night	10	9:30 a.m.	61	<u>D. funeralis</u> <u>D. busckii</u> <u>D. melanogaster</u>
Banana 2	Manhattan	over-night	18	9:30 a.m.	61	<u>D. americana</u> <u>D. melanogaster</u>
Banana 3	Manhattan	over-night	21	9:30 a.m.	61	<u>D. robusta</u> <u>D. repleta</u> <u>D. melanogaster</u>
Persimmon 1	Manhattan	over-night	11	4:00 p.m.	56	<u>D. melanogaster</u> <u>D. affinis</u>
Persimmon 2	Manhattan	over-night	13	4:00 p.m.	56	<u>D. melanogaster</u> <u>D. affinis</u>
Persimmon 3	Manhattan	over-night	9	4:00 p.m.	56	<u>D. melanogaster</u> <u>D. affinis</u> <u>D. americana</u>
Banana 1	Manhattan	over-night	15	9:30 a.m.	65	<u>D. repleta</u> <u>D. robusta</u> <u>D. melanogaster</u>

Table 6. (cont.)

Type & number of trap baits used	Kansas locality	Time exposed	Approx. no. hrs.	Time of capture	Temperature	Species represented.	Remarks
Banana	2 Manhattan	over-night	13	9:30 a.m.	65	D. melanica D. lusca D. melanogaster T. athabasca	
Banana	3	over-night	19	9:30 a.m.	65	D. funebris D. americana D. robusta D. melanogaster	
Crab apple	1 ( <i>Malus</i> <u><i>domestica</i></u> )	over-night	6	2:00 p.m.	57	D. robusta D. melanogaster	
	2	over-night	8	2:00 p.m.	57	D. alegrequin D. affinis D. repleta D. melanogaster	
	3	over-night	5	2:00 p.m.	57	D. funebris D. melanogaster	
Hopa crab	1 ( <i>Salus</i> <u><i>baccata</i></u> )	over-night	5	3:00 p.m.	57	D. melanica D. melanogaster L. affinis	
	2	over-night	9	3:00 p.m.	57	D. robusta D. melanogaster L. affinis	
Apple	Dodge City	over-night	none	none	52	None	

Table 6. (concl.)

Type & number of trap baits used:	Locality	Time exposed:	Approx. no. of hrs.:	Specimens caught:	Time of collection:	Temperature of collection:	Species represented.	Remarks
Apple	McPherson	over-night	none		5:00 p.m.	58	None	
Grape	1 Wathena	72	35		3:00 p.m.	unknown	D. <u>repleta</u> D. <u>melanoaster</u> D. <u>Funeturis</u>	
	2 Wathena	72	32		3:00 p.m.	unknown	D. <u>melanoaster</u> D. <u>Funeturis</u> D. <u>affinis</u>	
Apple	Wathena	72	23	none	3:00 p.m.	unknown	D. <u>melanoaster</u>	
Banana peels	Norton					unknown	None	
Banana peels	Edmond	over-night	none			unknown	None	
Banana peels	Manhattan	week	33	9:30 a.m. and 4:30 p.m.	60 <sup>1</sup>	D. <u>hydei</u> D. <u>trifunctata</u> D. <u>funeturis</u> D. <u>busckii</u>		
					62	D. <u>funeturis</u>		
					73	D. <u>funeturis</u>		
					74	D. <u>affinis</u>		
					75	D. <u>affinis</u>		
					79	D. <u>melanoaster</u>		
							Exposed through the week; made 2 collections per day.	

<sup>1</sup> An average daily temperature ranging from 60° to 79° F. for six days.

fruits and trapped flies on bananas and apples were collected from Lyon, Neosho, Montgomery, Cowley, Barber, Stafford and McPherson counties. The traps were distributed in and out of the city limit of each town or city. Some traps were placed near fruit stands and others under fruit trees and garbage cans. The traps were either exposed overnight or two hours in each county (Table 6).

A trip to Wathena, Kansas was made on October 15, 1951 to collect Drosophilidae primarily on apples and grapes. In the apple orchards, countless numbers of decaying or rotting apples were on the ground and many of them were infested with these flies. Traps were exposed and collected by Mr. Elbert Eshbaugh around the apple orchards and grape vineyards at Wathena (Table 6).

During trips to northwest and southwest Kansas, Dr. R. H. Painter exposed traps with banana peels and apples in Norton, Washington, McPherson and Ford counties.

Various host fruits infested by species of Drosophilidae gathered during the fall of 1950 and 1951 are indicated in Tables 3 and 4. The common hosts that were infested in the state of Kansas were used in a comparative study. Some of the common fruits were pear, peach, persimmon, apple, wild grape, cultivated grape, crab apple and prickly pear. Other hosts used were vegetables, fungi, and berries.

### Time, Humidity, and Temperature Most Favorable for Trapping

Trapping of Drosophilidae requires a knowledge of their ecology and physiology. The distribution of species can be determined partly through a study of collection data which is based on particular species and their habitat.

A slightly shaded area close to a decaying vegetable or fruit was found to be best for collecting Drosophilidae. The best time for collecting flies was found to be from 8:30 to 10:30 a.m. and from 4:00 to 5:00 p.m. Also, when the day was cloudy with high humidity at a temperature of 80° F., there was an increase in the numbers of the flies caught. One of the limiting factors in trapping the flies is rain. The rainfall, varying in amount, can ruin the catch and trap by filling the jar with water. It is difficult to find a completely sheltered area where a trap can be placed, unless beneath a roof of a house or similar structure.

All during this time of collecting, the temperature from September 15 to September 30 ranged from 60° to 85° Fahrenheit. The temperature best suited for collecting flies ranged between 75° to 85° Fahrenheit. Although time and humidity are mentioned separately, all three (time, humidity and temperature together) play an important role in the abundance of flies.

The temperature (Fig. 3) and the humidity (Fig. 4) were

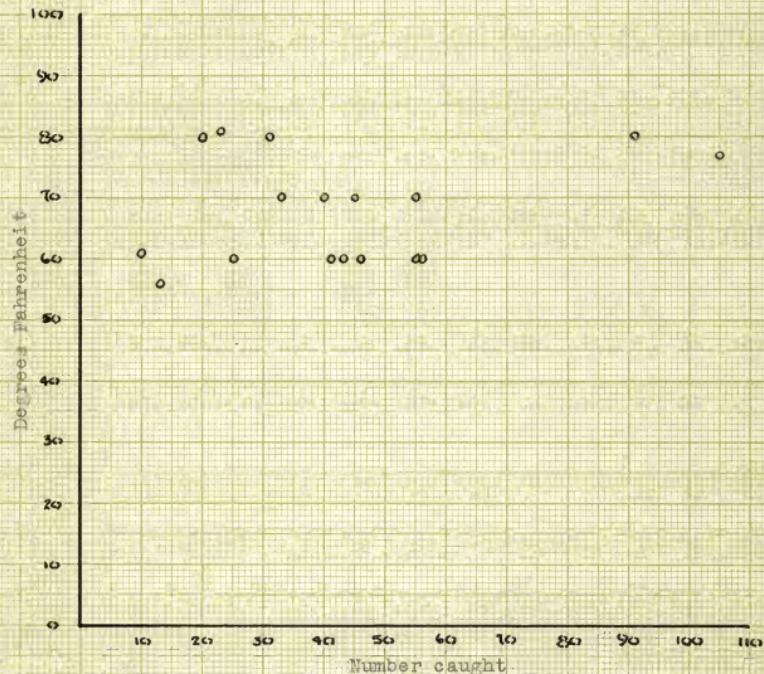


Fig. 3. Number of species of *Drosophila* caught in relation to temperature recorded in Fahrenheit.

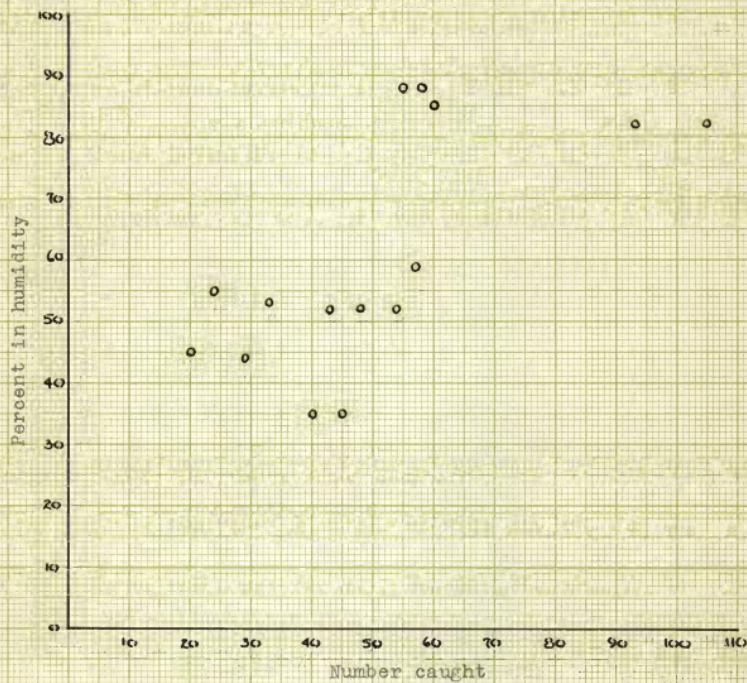


Fig. 4. Number of species of *Drosophila* caught in relation to percentage in humidity.

plotted against the trapping of flies during the fall of 1950 from September to October in Manhattan area. A closer relationship is indicated between the number of species caught in relation to percentage of humidity than to that of temperature. The humidity factor, as well as lowering of the temperature, probably has much to do with the fact that flies come to traps in large numbers immediately before or after a rain. These flies were unable to venture to the traps during a high wind.

The temperature and humidity data are derived from hydro-thermograph charts at Kansas State College Department of Physics.

#### Rearing

In the laboratory each day, the jars were examined for a possible new generation from the infested fruits. After three to four days, varying numbers of tiny (0.5 mm) larvae were seen crawling on the fruit in the jars. They fed on the food for about four to six days at 75° to 80° F. room temperature until they were ready to pupate. The full grown larvae were white, legless, and 1 mm to 1.5 mm long. The full grown larvae attached themselves to the paper towel by the secretion of a silk-like substance. The cuticular wall of the larva changed into a puparium. Five to six days were approximately the length of the puparial stage. A single generation required from 14 to 16 days. The length of the life cycle depended on the quality of

the media and the temperature.

Ripened fruits or berries were collected for possible dormant eggs or other stages and were brought back to be reared under favorable conditions. The fruits were placed in the jars and a dash of water was sprinkled upon them. The jars were tightly covered with cheese cloth. Under room temperature, the eggs would be expected to hatch into larvae. Two weeks later, molds began to grow in one of the jars; and day by day, the molds increased in size. The wild grapes did not develop any mold infestation but instead, several Drosophila flies emerged. A tentative reason for the lack of development of flies on other berries and fruits was first, the berries were too dry and second, Drosophila require a fermenting fruit or a berry undergoing decay (Plate I).

A rearing oven was used in some cases to keep the culture at a constant temperature because the temperature in the room varied between 10 to 20 degrees Fahrenheit. The rearing oven may have been a failure because the carbon dioxide did not escape freely from the oven. All of the flies in the oven were dead. Whenever the oven was opened, the pungent odor spread over the entire room. This experiment was repeated several times by placing new cultures in the oven.

EXPLANATION OF PLATE I

Methods used in the study of Drosophilidae

Fig. 1. Fruit infested by Drosophilidae in a glass container enclosed by cheese cloth.

Fig. 2. Culture media used as baits for trapping Drosophilidae.



PLATE I

FIG. 1.

FIG. 2.

2.53297

## METHOD OF CONTROL

## Insecticidal Control Test

The insecticides used in this experiment were from three commercial brands. The first was the Cooper-Chlor #4.

The second insecticide used in the experiment was Lindex We-10 (containing lindane).

The third was Pestroy, 25 per cent DDT concentrate with a resin base.

Small Scale Field Applications With  
Three Insecticides

During the first test a 0.5 per cent water emulsion of DDT prepared from 25 per cent concentrate of DDT, 0.2 per cent water emulsion of Lindane, and 0.2 per cent water emulsion of Chlordane were used. In each case, alternate insecticides were used in each city block. These solutions were applied at the rate of approximately 100 milligrams per square foot by painting the inside of the lid of the garbage can and around the outside of the top of the garbage can. Most garbage cans used were of three sizes; 12 inches, 14 inches, and 20 inches diameter.

The insecticides were painted on the garbage cans with paint brushes. The treated street blocks with insecticides are designated on Fig. 5. They were distributed mainly throughout

the central section of the city of Manhattan. The street blocks used were the 800, 900, and 1000 blocks between Moro and Laramie (east to west through the alley). Between Moro and Bluemont in 1200 block garbage cans were also painted. Other places were only designated home and neighbors of 1801 Poyntz Avenue, 1015 Thurston Street, 1729 Fairchild Street and 715 Fremont Street where three insecticides were used. Also the garbage cans were painted at the College Cafeteria, Mar's Cafe and Goodnow Courts. The applications of insecticides were made at two different times. The first application was made during the latter part of September, 1951 and the second in the earlier part of October, 1951.

The insecticides were applied during relatively warm days with little precipitation. The average precipitation during the week September 24 through September 30, 1951 was .075. The week following from September 30 to October 8, 1951 it was .061. And the average temperature for the week ending September 30 was 68° F. with the highest for the week 85° F. and the lowest, 34° F. The average for the following week, from September 30 through October 8, 1951 was 60° F. with the highest for the week 88° F. and the lowest 34° F.<sup>1</sup>

Methods used in measuring fly densities after insecticidal

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<sup>1</sup> Temperature and rainfall were taken from Climatological Data of Kansas and Kansas State College Department of Physics.

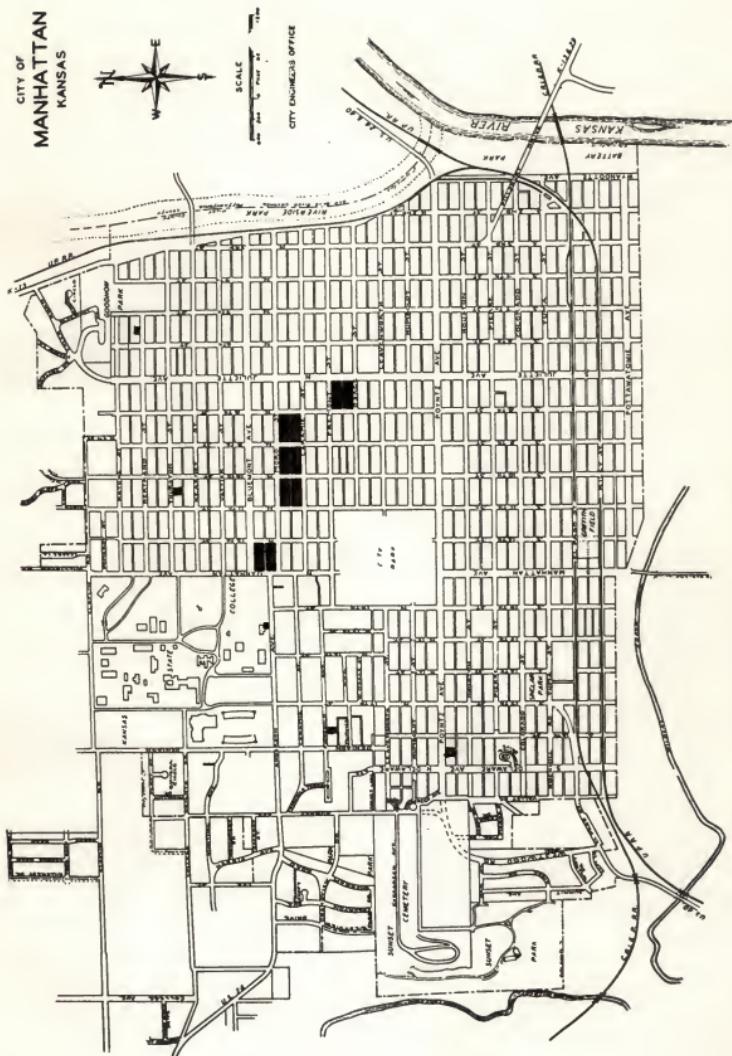


Fig. 5. Localities in Manhattan where tests of three insecticides were made by means of painting the garbage cans. Shaded areas indicate the insecticidal treatment for vinegar gnat control.

treatment were compared with the density of the pre-control population. After 48 hours, observations were made at each garbage can to detect the reduction of the fly population. The 0.5 per cent water emulsion of DDT showed a marked reduction of the fly population whereas 0.2 per cent lindane and chlordane gave less reduction of the fly population. To indicate the relative percentage of control, in several garbage cans there were approximately 15 flies prior to the treatment but next day there were zero to 10 living flies in the garbage cans. This was only a partial indication of what might be the effectiveness of the toxicants but it provided some evidence. However, all flies that entered the garbage can may not have died immediately. The chlorinated hydrocarbon insecticides have been relatively slow in action against the flies by means of contact (Shepard, 1951). Considering these facts, it appeared that there may have been 50 to 75 per cent control.

In a second application of insecticides, 0.3 per cent of lindane and chlordane were used. There were marked differences in the reduction of the fly populations. It was impossible to obtain 100 per cent control in all cases.

For further study, three empty five gallon lard cans were used to simulate garbage cans. Inside the cans, a mixture of ripe bananas, pears, and peaches was placed in quart bottles approximately in the center of the lard can. The inside of the lid and around the outside of the top of the garbage cans were painted with a mixture of 0.5 per cent DDT, 0.3 per cent

lindane and 0.3 per cent chlordane. The lids of the cans were left open just enough for the flies to crawl in and out the cans.

The average counts after 48 hours using 0.5 per cent DDT have been 3.2 dead flies in the fruit jar and 2.0 dead flies inside the can. With the 0.3 per cent lindane, there was an average of 3.4 dead flies in the fruit jar and 4.4 dead flies inside the can. The third can using 0.3 per cent chlordane there was an average of 2.8 dead flies in the fruit jar and 4.2 dead flies in the can.

The garbage can and the lard can experiments constituted evidence that about equal control can be secured from all three insecticides. A more extensive painting or spraying of insecticides might have caused better results.

#### CONCLUSION

The traps and naturally infested fruits were the chief sources for collecting species of Drosophilidae. Many types of baits were used, but fermented banana gave the best results. Some of the common fruits used were tomato, pear, peach, persimmon, apple, grape, crab apple and various berries. Other hosts were plant parts and fungi. In rearing, there were a few species, such as D. melanogaster which were reared from several substrates but others were closely related to a single substance. The substrates differed from one another by their

longer lasting quality. Also, certain substrates, such as persimmon, peach, apple, etc. attracted more flies than others. There were close relationships between substrates gathered during the fall of 1950 and 1951 which have had similar adult emergence of Drosophilidae.

There were several materials on which rearings were attempted which gave no indication of fly infestation. One possible reason for this failure might have been the temperature fluctuation during the time of the rearings. The temperature was extremely high during the day and very low during the night in the rearing laboratory. Also condensation of toxic matter might have inhibited the growth of Drosophilidae. Many of the materials during the time of rearing accumulated a great abundance of mold, due primarily to excess moisture in the rearing jars and to less air circulation within the jars.

The total number of specimens reared from wild hosts during the fall of 1950 and 1951 totaled 1,050 of which 455 were D. melanogaster. Roughly 50 per cent of the total number reared were D. melanogaster. Among approximately 1,469 specimens trapped during the fall of 1950 and 1951, at least 75 per cent were D. melanogaster.

Drosophila melanogaster flies were either trapped or reared 72 different times while Drosophila funebris was the second most common species with 8 different collections.

There were more flies in the fly traps brought in during the morning than during the afternoon hours.

An interesting species collected during the investigation was Mycodrosophila dimidiata which fed on fungus.

The study of the relationship of humidity and temperature with trapping was made at Manhattan during the fall of 1950. The highest percentage of flies was caught when the humidity ranged from 40 to 65 per cent. In other words, the humidity and the number of specimens caught during the period of study showed a positive relationship whereas any relationship between the temperature and the number of specimens caught was less evident within the range studied. Between 9:30 to 10:30 a.m. was the best time for collecting flies because a great number of Drosophilidae came to the baits at that time.

The field work with three insecticides on garbage cans was applied by painting the inside of the lid and outside of the top of the can. The evidence showed that some control can be secured by such means. To prevent Drosophilid infestation around homes, it is necessary to destroy the breeding places and adult females. The satisfactory and logical means of controlling the insects is the use of insecticides since satisfactory sanitation cannot be secured.

Since 1903, five genera and 11 species have been recorded in the list of Drosophilidae in Kansas. Among the four genera and 19 species collected during 1950 and 1951, there was one genus and 13 species not previously recorded in the list of species from Kansas. The latter include: Mycodrosophila dimidiata Loew., Drosophila algonquin Sturtevant and Dobzhansky,

Drosophila athabasca Sturtevant and Dobzhansky, Drosophila americana Spencer, Drosophila guttifera Walker, Drosophila hydei Sturtevant, Drosophila immigrans Sturtevant, Drosophila melanica Sturtevant, Drosophila putrida Sturtevant, Drosophila robusta Sturtevant, Drosophila repleta Wollaston, Drosophila tripunctata Loew. and Drosophila simulans Sturtevant.

There were four species of Drosophilidae collected in Kansas but not recorded in any of the four states bordering the state of Kansas. These species are: Mycodrosophila dimidiata, Leucophenga maculosa, Leucophenga varia, and Drosophila americana.

The most commonly known species from Kansas and also from Missouri, Oklahoma, Colorado, Nebraska were D. funebris, D. hydei, D. melanogaster, D. simulans, D. putrida, and D. busckii.

#### SUMMARY

The species of vinegar gnats (Drosophilidae) and their control have been studied under the conditions prevailing in Kansas.

The Drosophilidae are not of economic importance as far as direct damage is concerned, but because of their great abundance in homes they become very annoying.

During the fall of 1950 and 1951, baits were used for trapping Drosophilidae. As attractants (baits), nine types of fruits were used. Because of the natural attraction of the insect to the odor and the longer lasting of the fruit, banana

was selected as the best bait. Also culture media were made to use in the traps procedure. The fruits were placed in the mayonnaise jars as traps in the Manhattan area and in several counties in Kansas.

Flies were also collected by sweeping the net over the infested or decaying vegetables and fruits.

Various hosts, such as fruits, fungi and plant parts, infested by Drosophilidae were collected in September and October 1950 and 1951. Some of the common fruits used were tomato, pear, peach, persimmon, apple, grape, crab apple and various berries. Most species of Drosophilidae, except D. melanogaster and D. simulans, were collected only on specific substrates.

An interesting species collected during the investigation was Mycodrosophila dimidiata which fed and bred on fungus.

Time, humidity, and temperature were the important elements concerned in successful trapping of Drosophilidae. Between 9:30 to 10:30 a.m. was the best time for collecting flies because of great numbers of Drosophilidae coming to the baits at that time.

The study of the relationship of humidity and temperature with trapping was made at Manhattan during the fall of 1950. The humidity and the number of specimens caught during the period of study showed a relationship whereas any relationship between the temperature and the number of specimens caught was less evident within the range studied.

Among the 72 collections from traps, there were only 8 without flies or approximately 10 per cent unsuccessful collections.

Among 22 different kinds of materials from which rearings were attempted, flies emerged from 10 substrates. This is approximately 55 per cent without infestation by Drosophilidae.

The field work with three insecticides on garbage cans was applied by painting the inside of the lid and the outside of the top of the can. The evidence showed that some control can be secured by such means. To prevent Drosophilidae infestation around homes, it is necessary to destroy the breeding places and adult females. The satisfactory and logical means of controlling the insect requires the use of insecticides when satisfactory sanitation cannot be secured.

During these studies, four genera and 19 species have been collected and reared. From the total number of species, there were 13 species not previously recorded from Kansas including one belonging to a previously unreported genus.

There were four species of Drosophilidae collected in Kansas but not recorded in any of the four states bordering the state of Kansas. These species were: Mycodrosophila dimidiata, Leucophenga maculosa, Leucophenga varia, and Drosophila americana.

The species Scaptomyza adusta, D. tripunctata, D. athabasca, and D. repleta represent the farthest north that these species have been found.

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## LITERATURE CITED

Aldrich, J. M.  
A catalogue of north American diptera. Smith. Misc. Coll. 46(2): 641-644. 1905.

Balufus, A. H.  
The fruit fly, Drosophila melanogaster Meig. Turtox News. 14: 92. 1936.

Bonde, R.  
The role of insects in the dissemination of potato blackleg and seed-piece decay. Jour. Agr. Res. 59(12): 889-917. 1939.

Bridges, D. B.  
Gametic and observed ratios in Drosophila. Amer. Nat. 55: 52. 1921.

Bridges, C. B. and H. H. Darby.  
Culture media for Drosophila and the pH of media. Amer. Nat. 67: 437-472. 1933.

Crevecoeur, F. F.  
Additions to the list of Kansas Diptera. Kans. Acad. Sci. Trans. 20(1): 96. 1905.

DeCoursey, R. M.  
A practical control for the pomace fly. Jour. Econ. Ent. 18: 626-629. 1925.

Demerec, M., ed.  
Biology of Drosophila. New York: John Wiley. 632 p. 1950.

Dove, W. E.  
Myiasis of man. Jour. Econ. Ent. 30: 29-39. 1937.

Titman, L. P., E. N. Cory, and A. R. Buddington.  
The vinegar gnats or pomace flies--Their relation to the canning of tomatoes. Md. Agr. Expt. Rep. 91: 111. 1937.

Dobzhansky, T. H. and Carl Epling.  
Contributions to the genetics, taxonomy, and ecology of Drosophila pseudobscura and its relatives. Carnegie Inst. Wash. Publ. 554: 179 p. 1944.

Galtsoff, P. S., ed.  
Culture methods for invertebrate animals. New York: Comstock Pub. Co. 589 p. 1937.

Geisler, Sister F. S.  
Effects on humidity of Drosophila melanogaster pupae.  
Amer. Nat. 76: 223-224. 1942.

Kalmus, H.  
A factorial experiment on the mineral requirements of a  
Drosophila culture. Amer. Nat. 77: 376-380. 1943.

Kalmus, H.  
Action of insecticide dust on insects. Review Appl. Ent.  
33: 88-89. 1945.

Lewis, M. T.  
A new agar medium for Drosophila culture. Science. 96:  
282. 1942.

McDaniel, E. I.  
Flies and mosquitoes commonly found about Michigan homes.  
Mich. Agr. Expt. Sta. Bul. 144: 14-15. 1935.

McLeod, W. S.  
Further refinement of a technique for testing contact  
insecticides. Canad. Jour. Res. Sec. D. 22: 87-104.  
1944.

Metcalf, R. L.  
Insecticidal properties of fluorine analogs of DDT.  
Jour. Econ. Ent. 41: 416-421. 1948.

Northrop, J. H.  
The effect of prolongation of the period of growth on the  
total duration of life. Jour. Biol. Chem. 32: 123-126.  
1943.

Parker, D. R.  
Moldex-A as a mold inhibitor. Drosophila Information  
Service. 4: 65. 1935.

Patterson, J. T., and M. R. Wheeler.  
The classification of the genus Drosophila, with de-  
scriptions of nine new species. Univ. Texas. Pub. 4213:  
109 p. 1942.

Patterson, J. T.  
The Drosophilidae of the Southwest. Univ. Texas Publ.  
4313: 7-216. 1943.

Pavan, C., T. H. Dobzhansky and H. Burla.  
Diurnal behavior of some neotropical species. Ecology.  
31: 36-43. 1950.

Shepard, Harold H.  
The chemistry and action of insecticides. New York:  
McGraw-Hill. 504 p. 1951.

Sloan, W. J. S.  
The control of tomato pests. Queensland Agr. Jour.  
61(1): 17-41. 1945.

Smart, J.  
A handbook for the identification of insects of medical  
importance. London: Jarrold and Sons, Ltd. 1943.

Spencer, W. P.  
A new technique for the study of Drosophila eggs and  
larvae. Science. 85: 298. 1937.

Spieth, H. T.  
The breeding site of Drosophila lacicola Patterson.  
Science. 113(2931): 232. 1951.

Snow, F. H.  
A preliminary list of the diptera of Kansas. Kans. Univ.  
Sci. Bul. 2(5): 211-223. 1903.

Stultz, H. T.  
Methods and materials of a new technique for using pomace  
fly in biological tests with contact insecticides. Ent.  
Soc. Ontario Ann. Report. 70: 72-80. 1959.

Sturtevant, A. H.  
The North American species of Drosophila. Carnegie Inst.  
Wash. Publ. 301. 150 p. 1921.

Tucker, E. S.  
Contributions towards a catalogue of the insects of Kansas.  
Kans. Acad. Sci. Trans. 20(2): 190-201. 1906.

Williams, D. D.  
The geographical distribution in the United States of  
Drosophila species collected in eastern Nebraska. Nebr.  
Acad. Sci. Proc. 58: 9. 1948.

STUDIES ON THE SPECIES OF VINEGAR GNATS  
(DIPTERA: DROSOPHILIDAE) IN KANSAS

by

CARL MASARU YOSHIMOTO

B. A., Iowa Wesleyan College, 1950

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